RICH Thermal Analysis and Test

M. Cova

RICH Requirements

- Operative Temperature Range

  [-30°C;+50°C]

- Non Operative Temperature Range

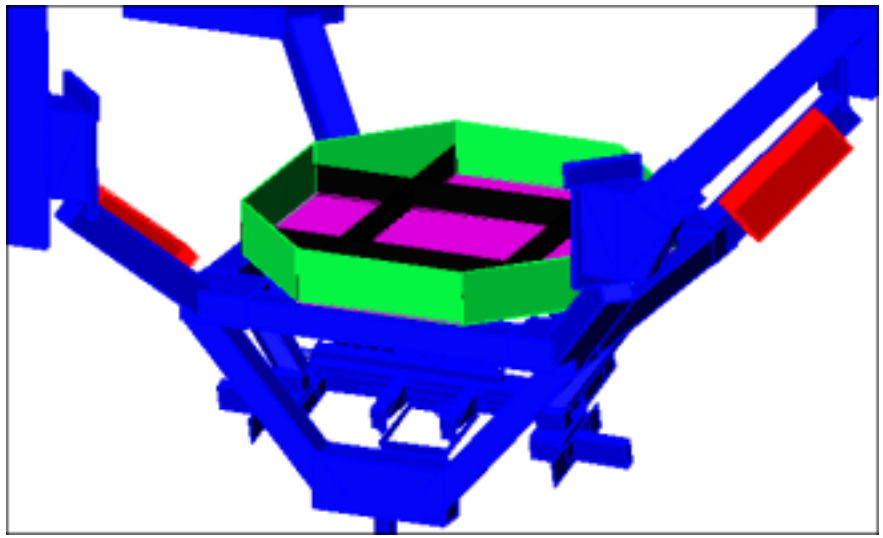
  [-35°C;+60°C]

  [-30°C;+50°C] non op. range has been updated by test results

- Temperature uniformity among the PMTs grid: 15°C
- Target (for physical purposes), temperature uniformity among single PMTs grid: 6°C

RICH Thermal model

- RICH bricks on USS02
- Rich&Ecal crates radiators no more in the model
- RICH outer panels covered by MLI



RICH dissipation

- PMTs =680 x 26mW=17.7W
- Boards =4 x 2W+ 4 x 0.45W=9.8W
- Mass saving activity 1st step (TIM 19/01/04):

  FEE on the detector
  =(1.7W+0.3W) x 4=8W
- Mass saving activity 2nd step (TIM 19/01/04):

  boards on the detector

  =1W + 1W=2W

37.5W

TOTAL **62 W**

–HV inside RICH ~ 7 W = 680 PM * (900 V**2 / 80*10**6 Ohm)

–LV inside RICH ~ 30 W = 14 (Preamp + ADC) + 4 (LVLR) +12(CDP)

–LV at R-Crates (2 Crates) ~ 9W

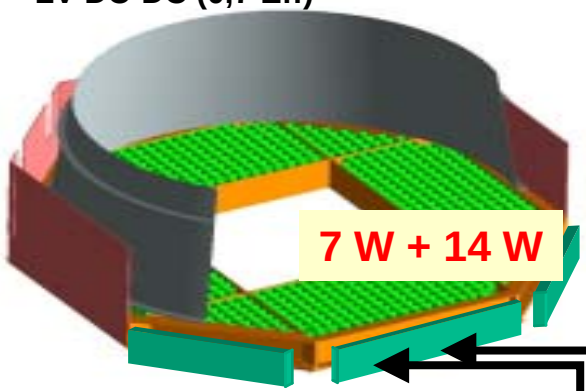
–2 * 1 JINF ~ 2 W = 2 * 0,3 A * 3,3 V

–2 * 2 USCM ~ 3 W = 2 * (0,2 Hot + 0,02 Standby) A * 5 V

–2 * 2 HV Control ~ 1 W = ?

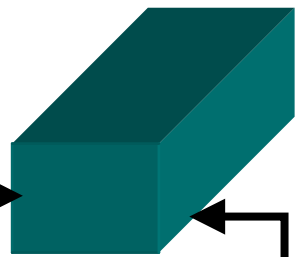
–2 * 2 HV Bricks (0,7 Eff) ~ 3 W = 6,88 / 0,7 - 6,88

–LV DC-DC (0,7 Eff) ~ 16 W = (6 + 30) / 0,7 - (6 + 30)



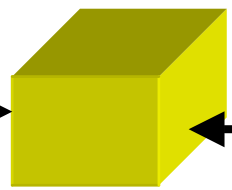
7 W + 14 W

12 W + 4 W



R-Crate

9 W

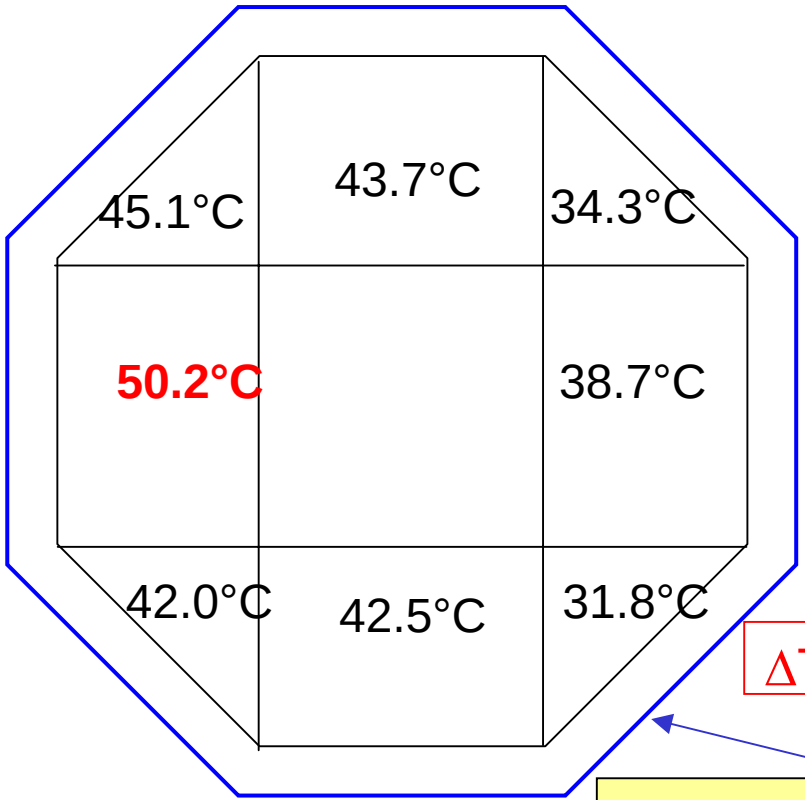


RPD 16 W

J. Marin

Thermal Analysis Results
-Hot cases-

HOT cases



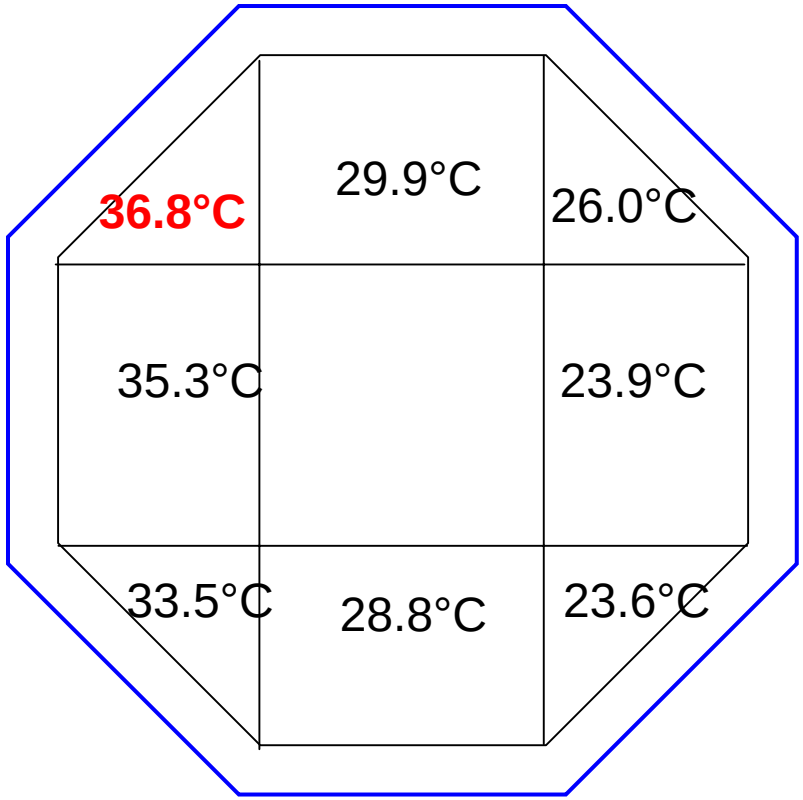
B-75_MPA_hot
Operative

55.2°C is the maximum PMT temperature prediction

ΔT=18.4°C

Values are maximum grid temperature for each grid.
5°C to be added to have PMT temperature

HOT cases

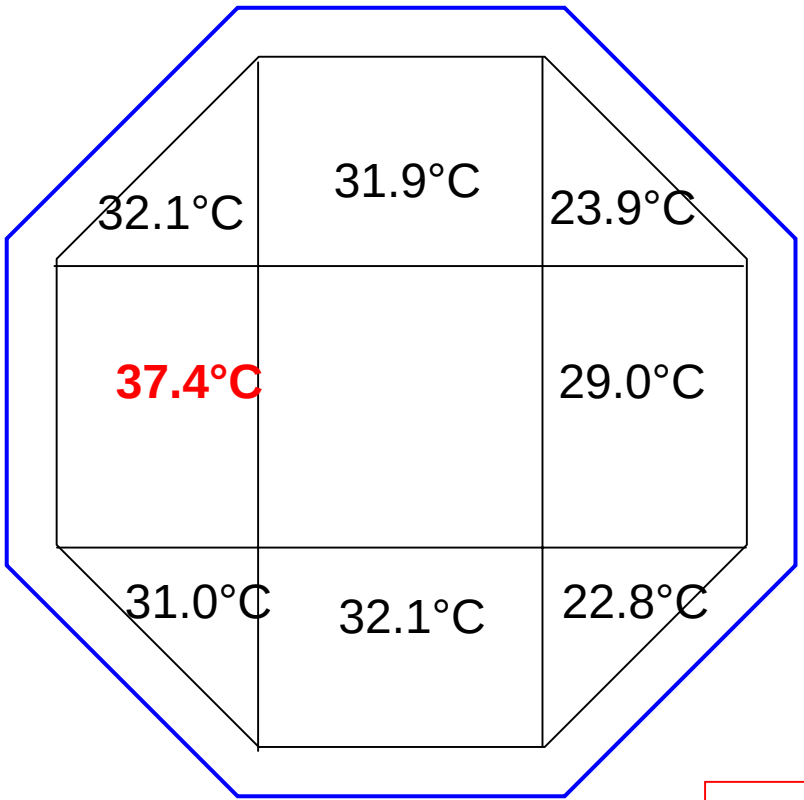


Grid Temperatures

B-75_MPA_hot
Non Operative

36.8°C is the maximum PMT temperature prediction (13.2°C margin)

HOT cases



Grid Temperatures

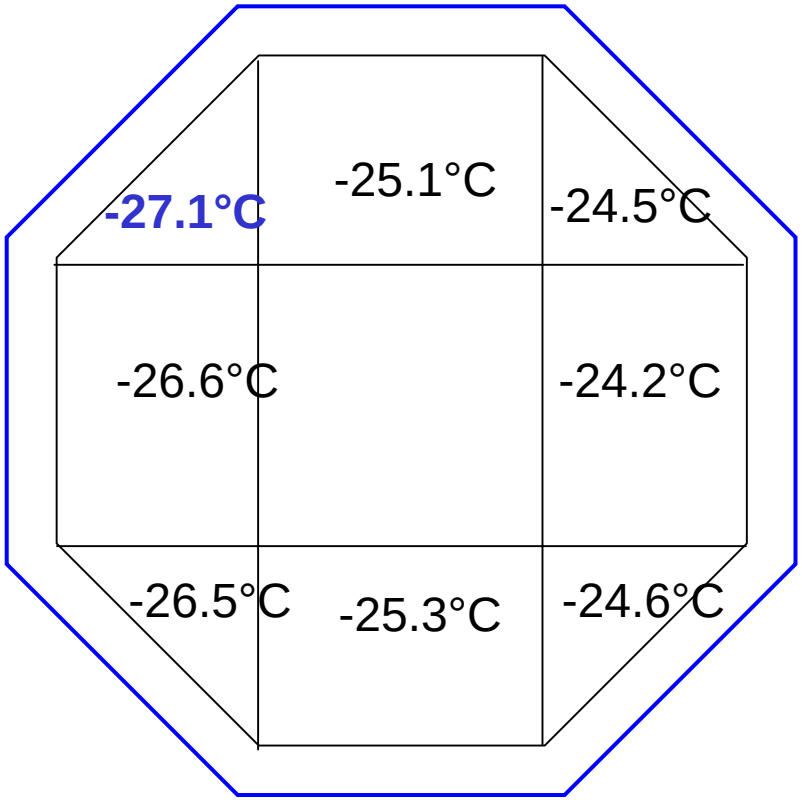
ΔT=14.3°C

B-60_MPA_hot
Operative

42.4°C is the maximum PMT temperature prediction (7.6°C margin)

Thermal Analysis Results
-Cold cases-

COLD cases



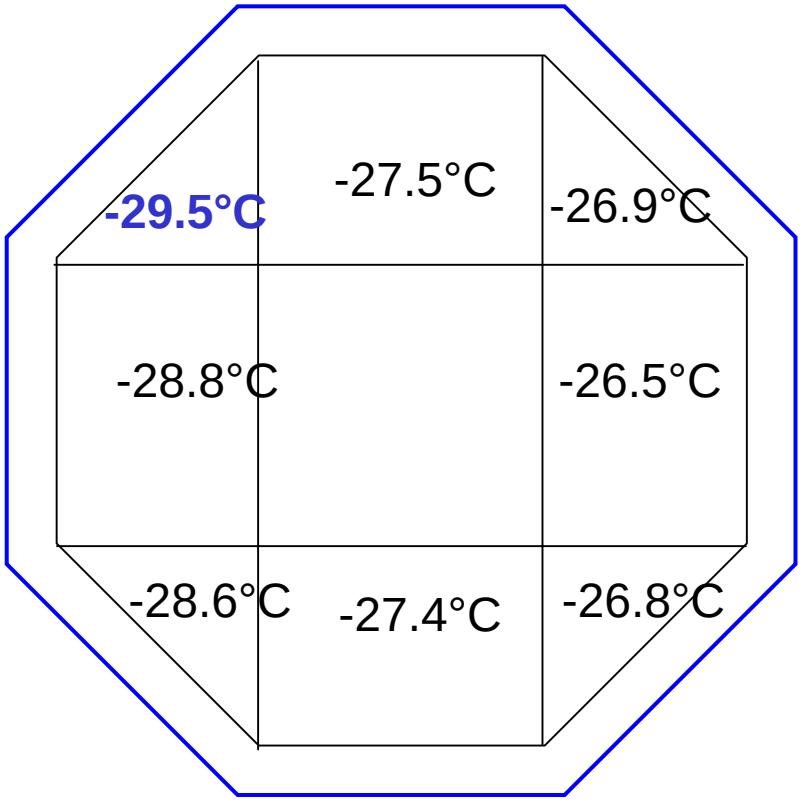
Grid Temperatures

B_0_MPA_cold
Non Operative

-27.1°C is the minimum PMT temperature prediction

Values are minimum PMT=grid temperature for each grid

COLD cases



Grid Temperatures

B_0_0_0-15_cold
Non Operative

-29.5°C is the minimum PMT temperature prediction

Conclusions

- HOT cases

The detector in the MPA attitude works for

$$-60° \leq \beta \leq +75°$$

and so it is ON for more than 95% of mission time.

In this range the thermal gradient inside whole detector is < 15°C

Conclusions

- COLD cases

Two different test campaigns have been foreseen:

1. 8 PMTs (EM) at –40°C → completed with positive results
2. 50 PMTs at –35°C → to be carried out for reasonable statistic.

Depending on second test result, heaters may be required (max continuous power in the worst cold case = 25W).

Thermal test philosophy

a) EM thermal test (8 PMTs with electronics and complete mechanics)
   a) 7 days at +60°C
   b) 7 days at -40°C
   c) 8 cycles between –40°C and +60°C

b) Qualification test (50 PMTs with electronics)
   - 7 days at +60°C
   - 7 days at -35°C
   - 8 cycles between –35°C and +60°C

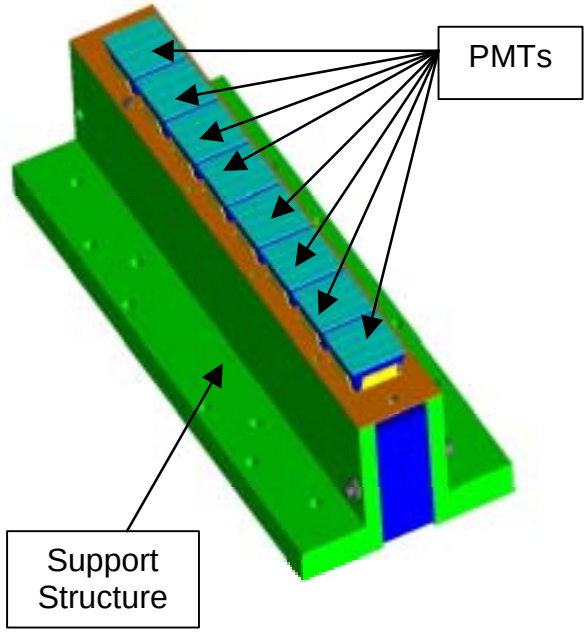
c) Acceptance test (on all the flight PMTs)
   - 7 days at +50°C
   - 7 days at -30°C
   - 8 cycles between –30°C and +50°C (TBC)

EM thermal test

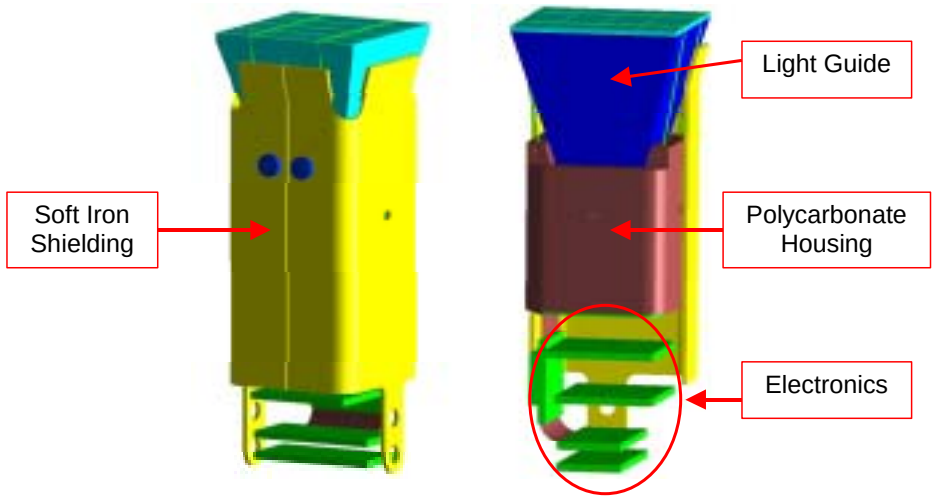
Scope

- Demonstrate the capability of the PMT with their electronics to work conforming to specification requirements after having experienced the non operative temperature range of –40°C to +60°C.
- Validate the thermal model of the sub-assembly using dummy power

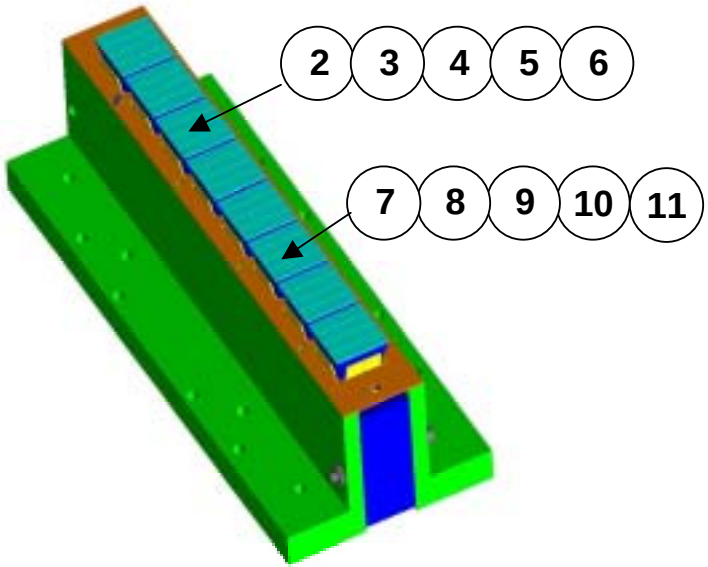
Test Article

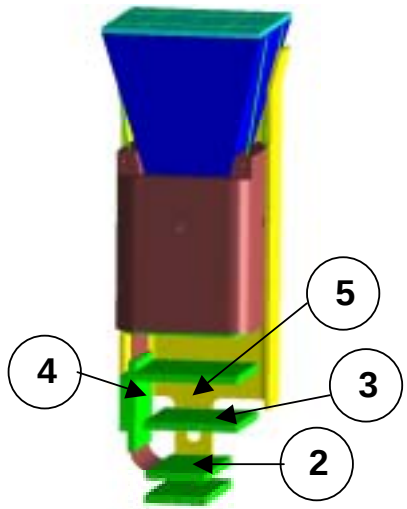


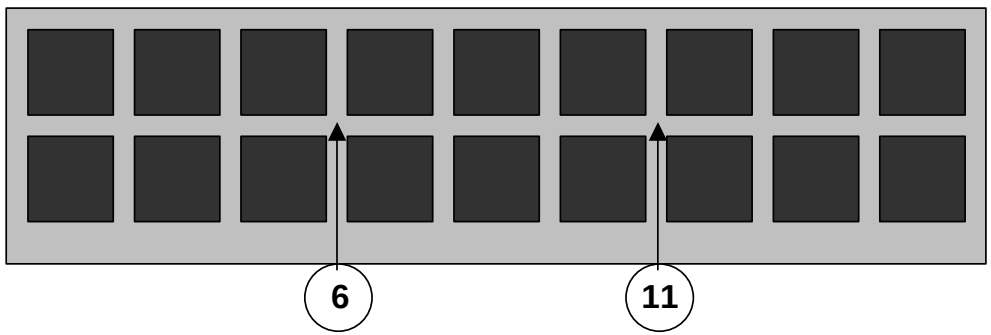
- 8 complete PMT assemblies
- Aluminum support structure



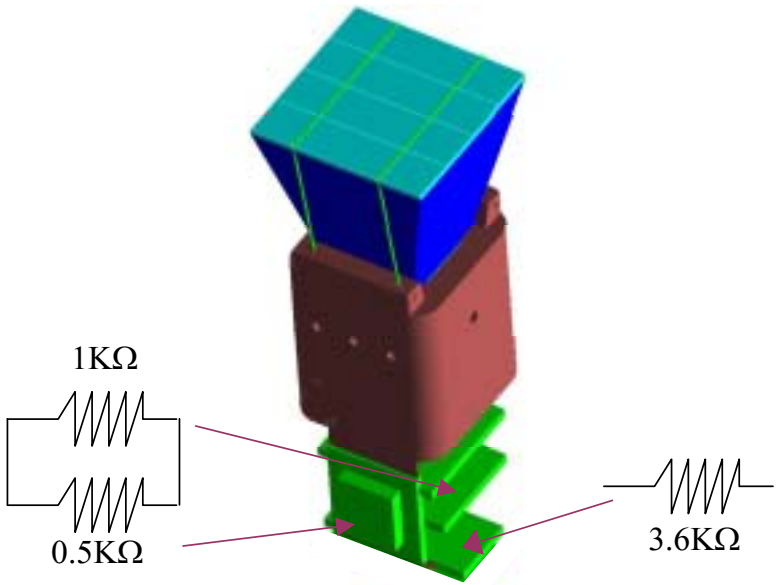
Sensors Position







Dummy power



- Real PMT dissipation

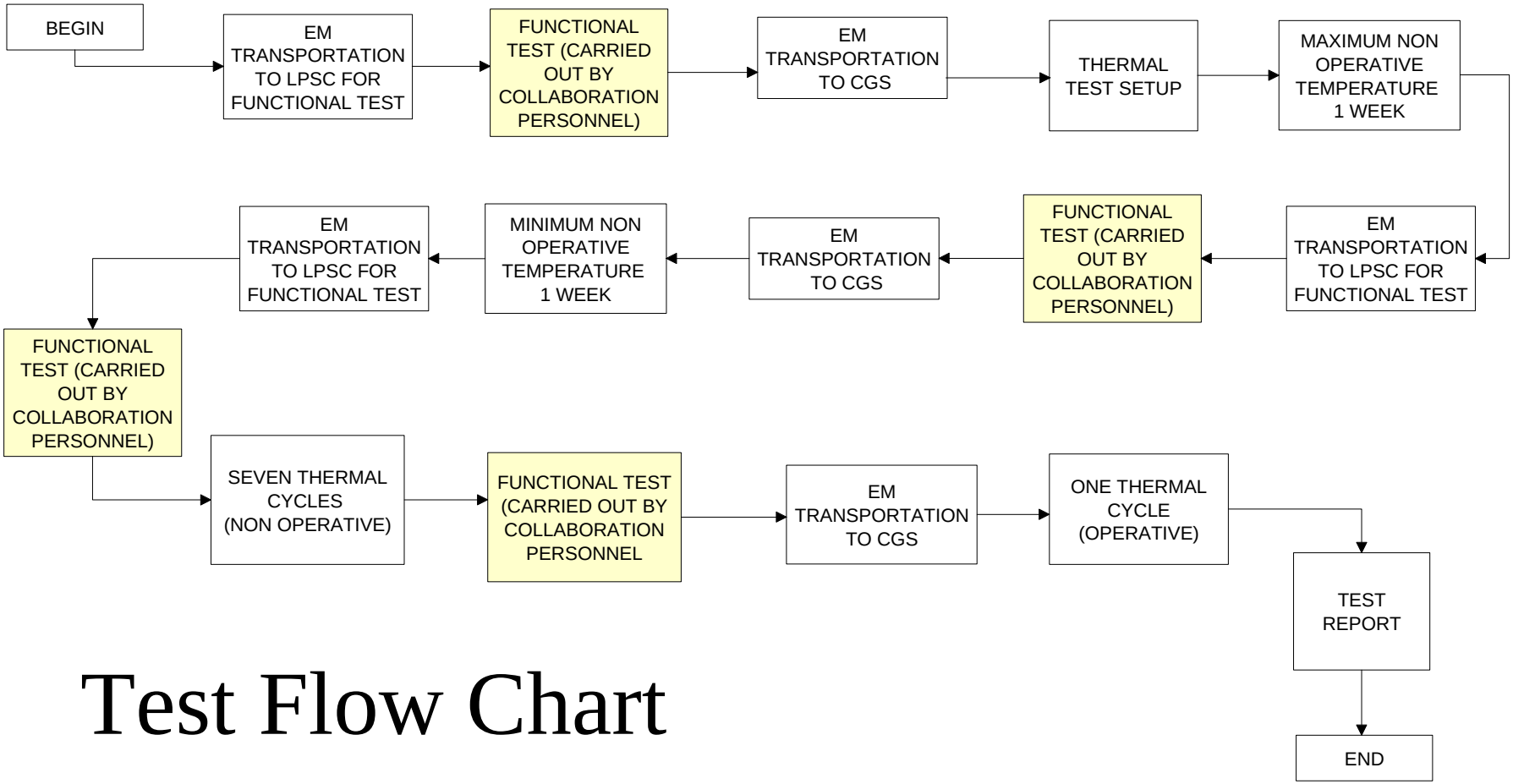
  26mW

- Dummy PMT dissipation

  1W

  in order to get reliable results and allow the model correlation

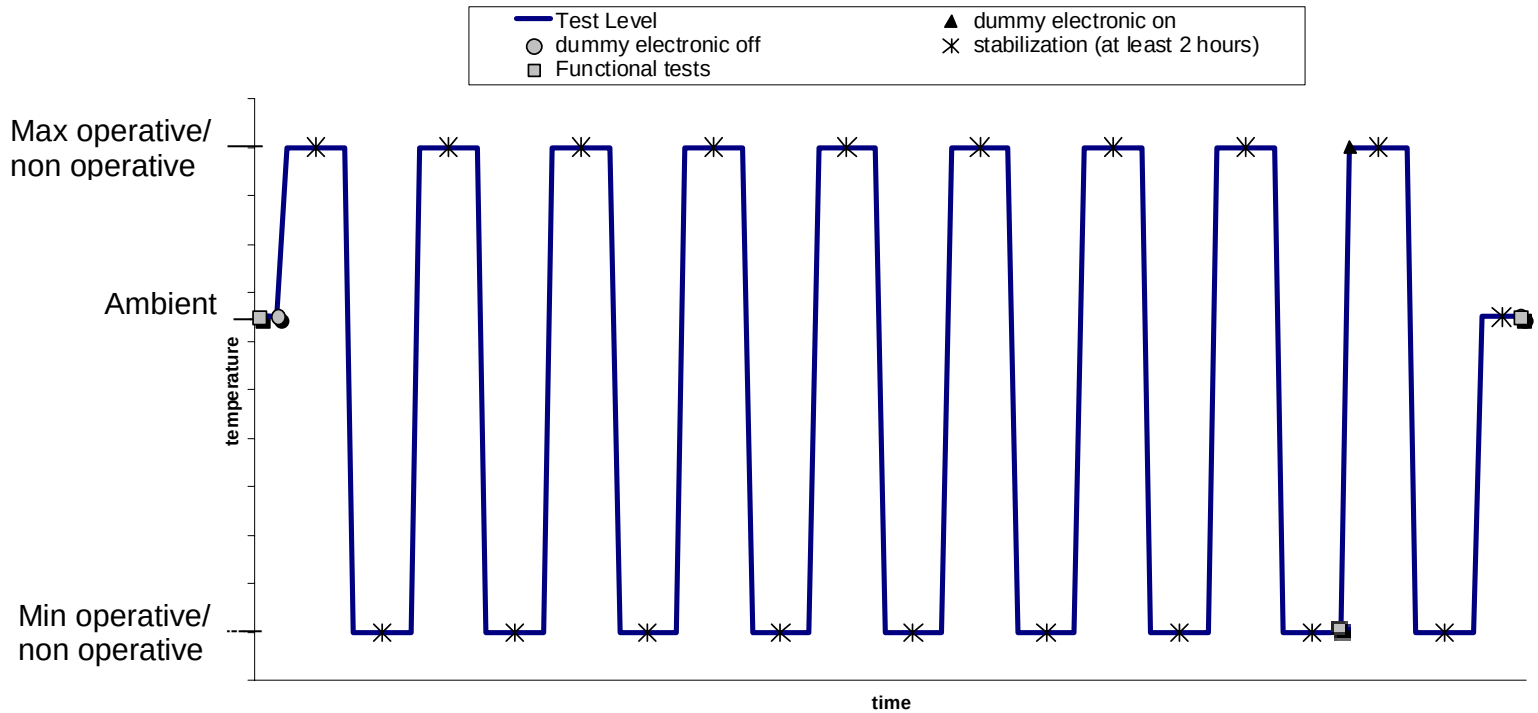
→ Ongoing test



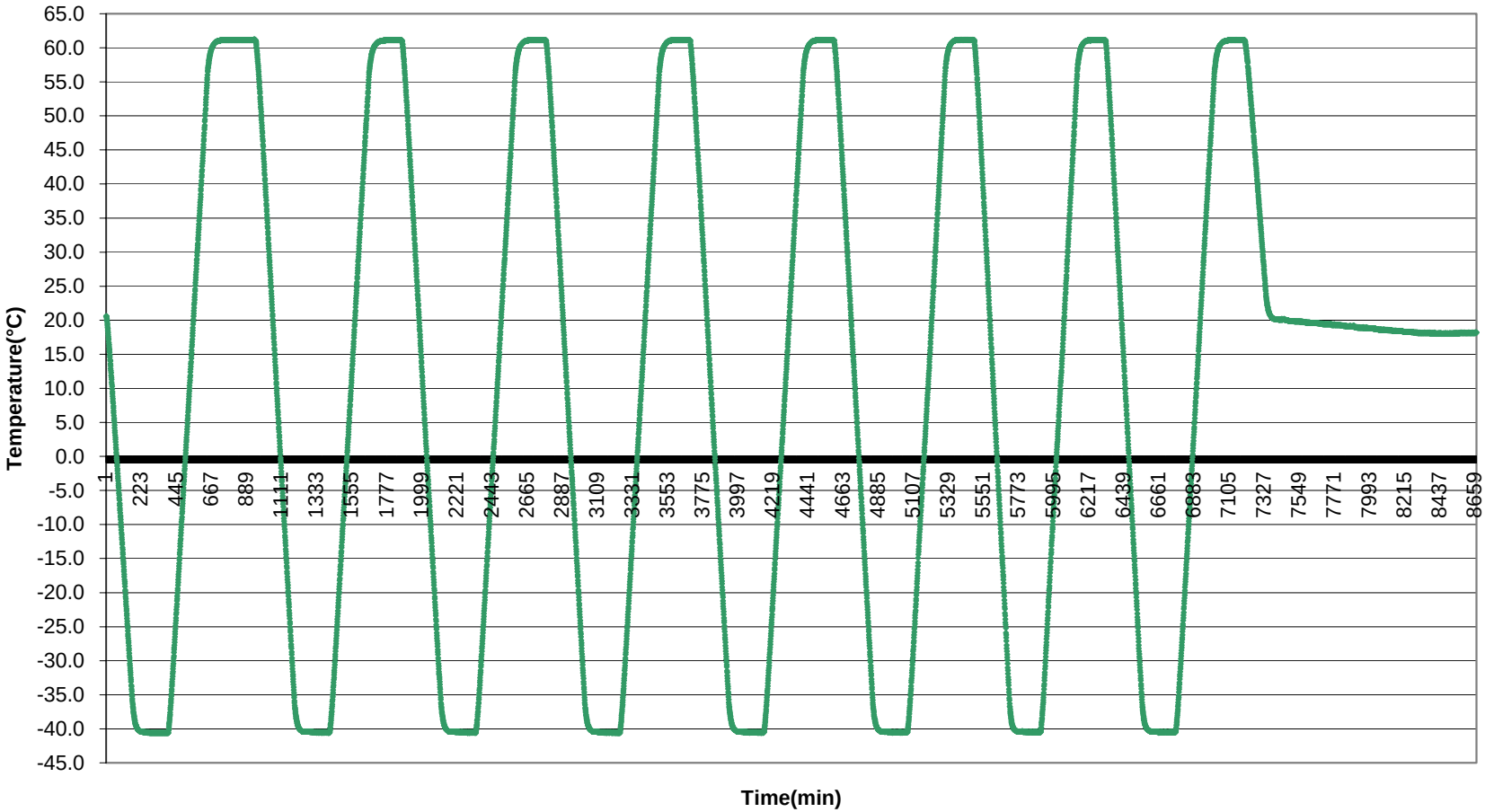
Test Flow Chart

Test Profile

- Max Op/non Op temperature = +60°C
- Min Op/non Op temperature = -40°C



Test results

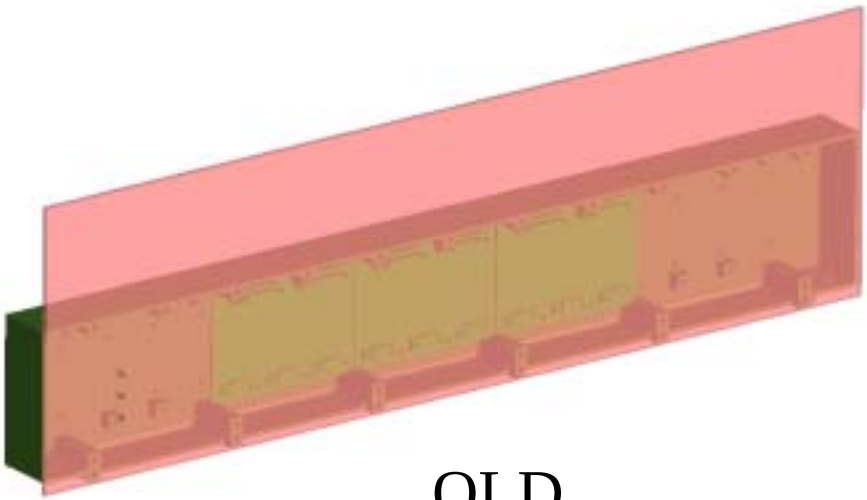


New RICH design (February 2004)

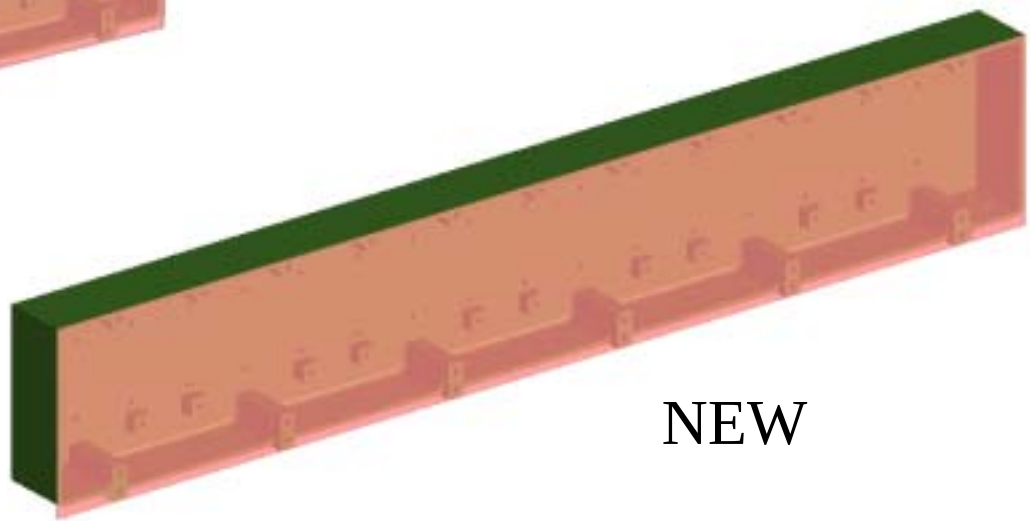
New RICH design

- Rational:
  - Old Radiators now working as heat path (“heat beams”)
  - “Heat beams” position not optimized due to several bad contact conductance
  - Bad connector and cables layout due to “old radiator” shape
  - Chance to save weight thanks to thermal cross section correct positioning

Panels

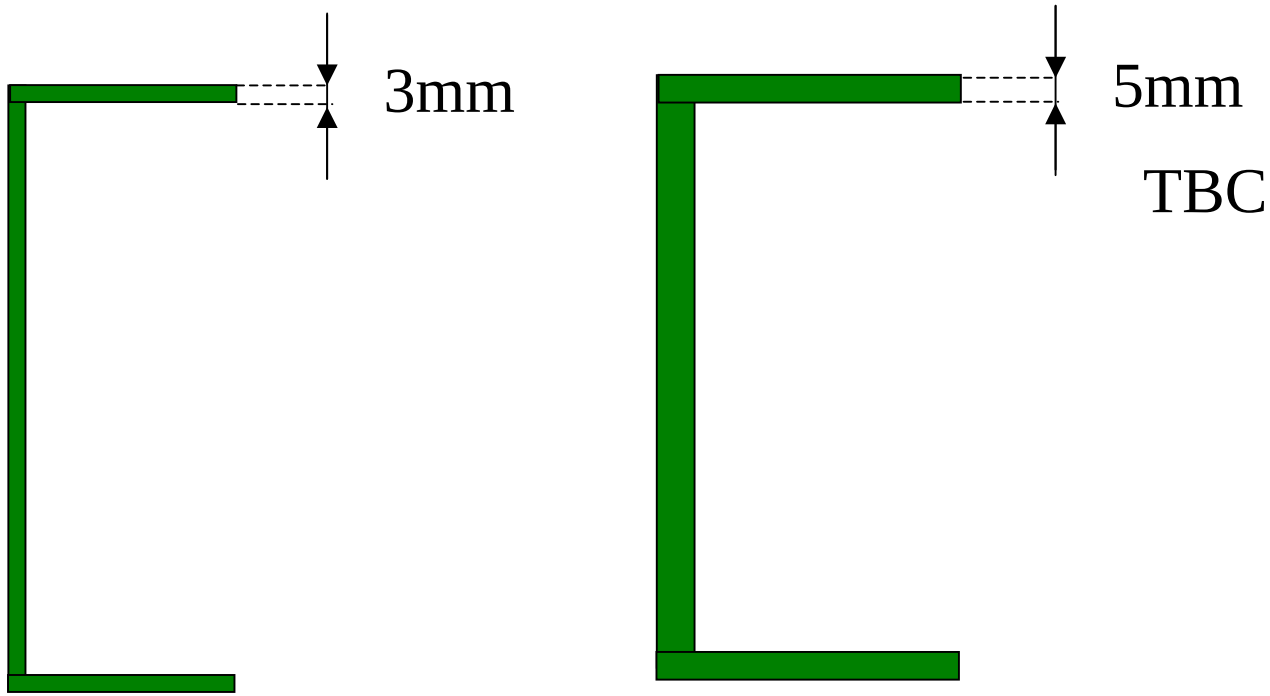


OLD



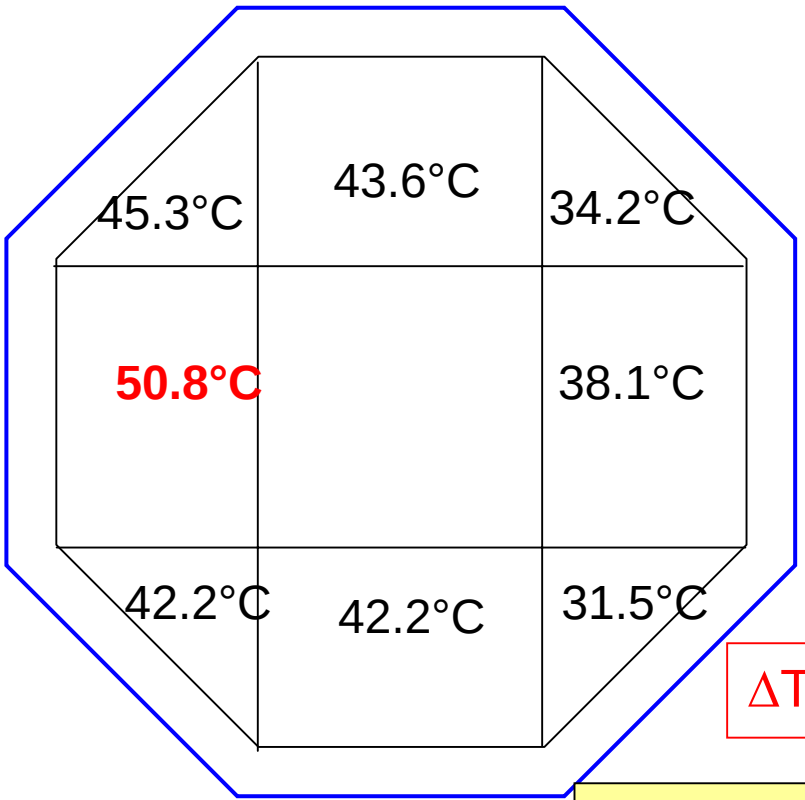
NEW

Octagonal Structure thickness



Analysis Results

HOT cases



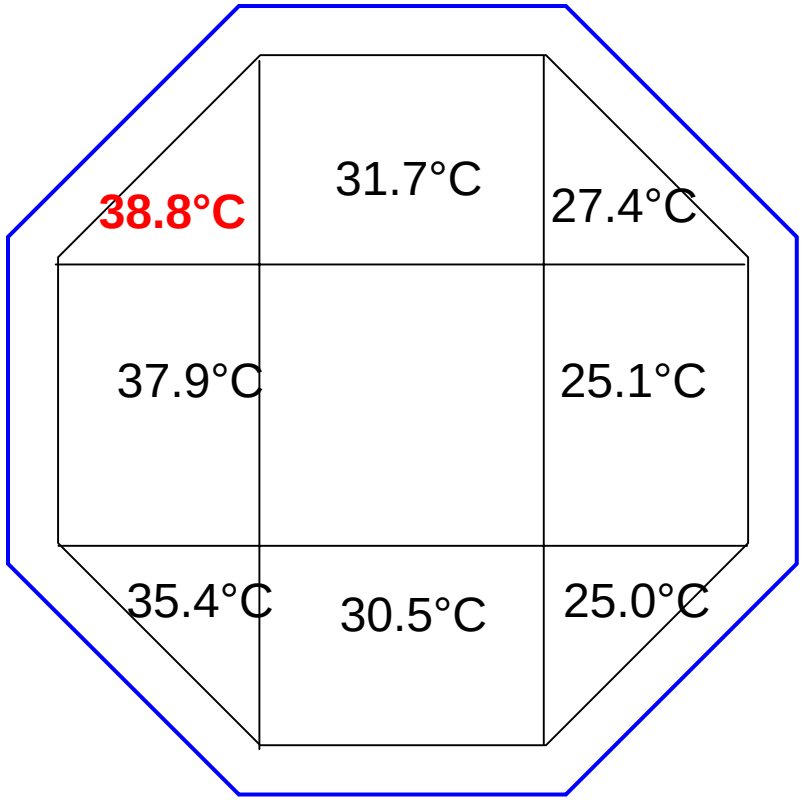
B –75_MPA_hot
Operative

55.8°C is the maximum PMT temperature prediction

ΔT=19.3°C

Values are maximum grid temperature for each grid.
5°C to be added to have PMT temperature

HOT cases

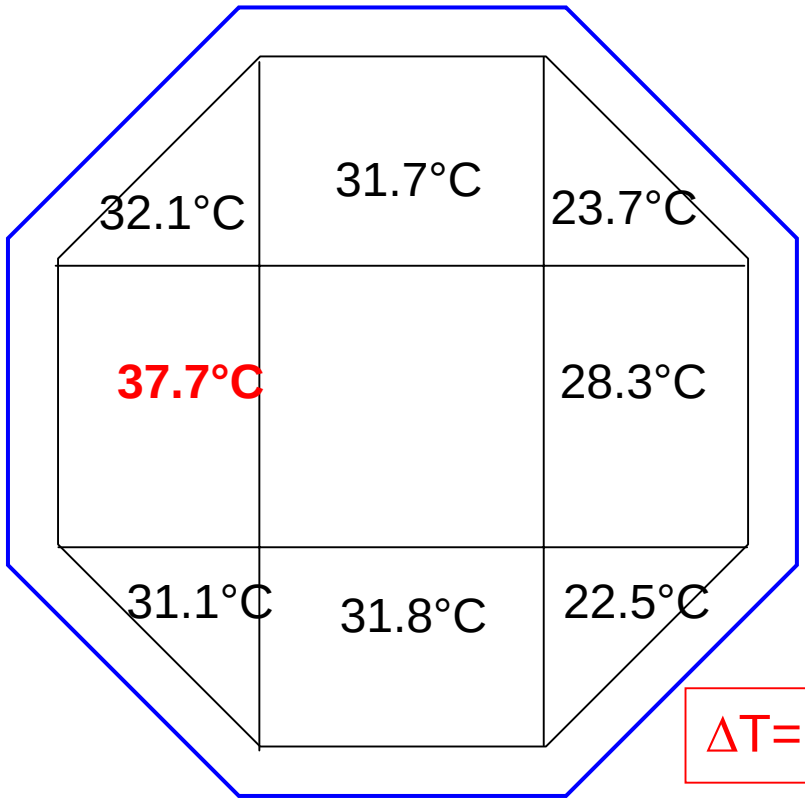


Grid Temperatures

B-75_MPA_hot
Non Operative

38.8°C is the maximum PMT temperature prediction (11.2°C margin)

HOT cases



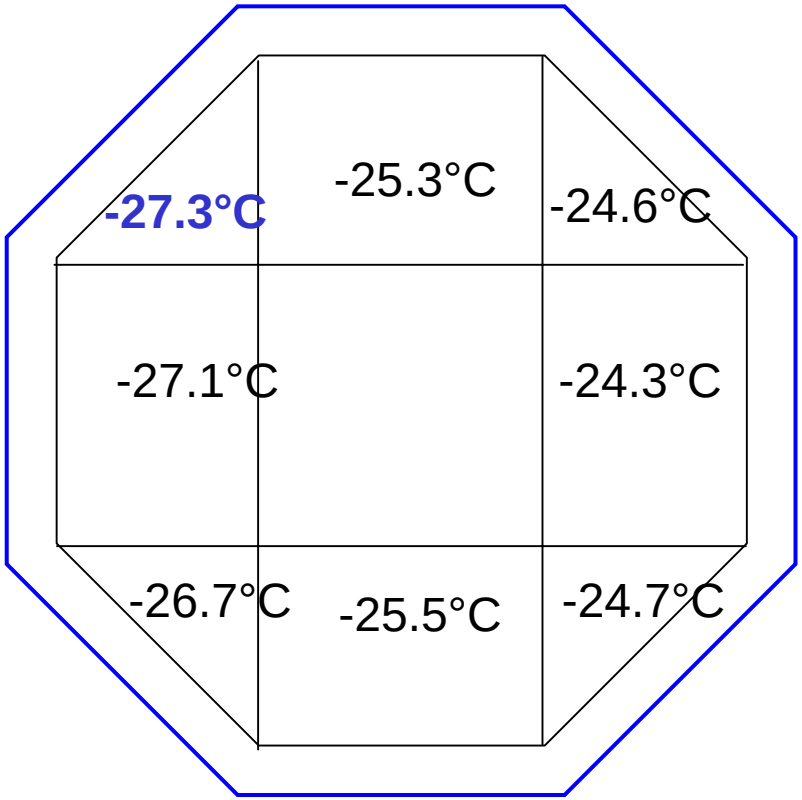
Grid Temperatures

ΔT=15.2°C

B –60_MPA_hot
Operative

42.7°C is the maximum PMT temperature prediction (7.3°C margin)

COLD cases



Grid Temperatures

B_0_MPA_cold
Non Operative

-27.3°C is the minimum PMT temperature prediction (2.7°C margin)

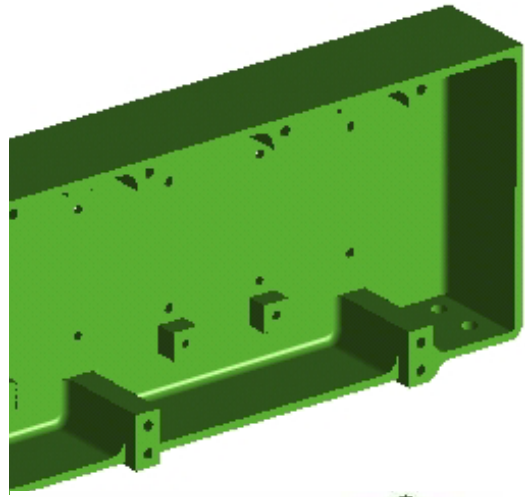
Values are minimum PMT=grid temperature for each grid

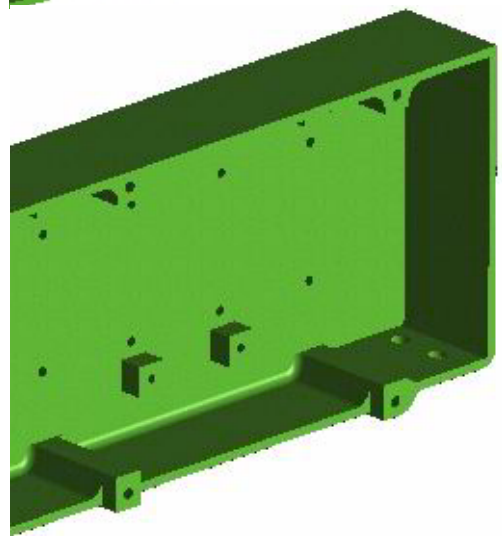
Mass saving

- OLD Thermal Panels ~ 10.7 kg
  Octagonal beams ~ 9.6 kg

- NEW cover panels ~ 1.4kg
  Δ(octagonal beams) ~ +5 kg
  Octagonal beams ~ 9 kg

-4.9kg





Conclusions

The new design gives 5 kg mass saving with same thermal results, TBC by structural analysis and electronic boards design

– HOT CASES

The detector in the MPA attitude works for

$$-60° \leq \beta \leq +75°$$

and so it is ON for more than 95% of time.

In this range the thermal gradient is in the worst case 15.2°C

Conclusions

– COLD CASES

Depending on test result (50 PMTs at –35°C for 7 days) , heaters may be required. (max continuous power in the worst cold case = 25W).